6.5.2.2.4.2 CFA-05. The total HI for CFA-05 for current and future occupational workers is 0.001 (Tables D-44 and D-46). This HI is well below the EPA threshold HI of 1.0. The estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.4.3 CFA-07. The estimated HI for CFA-07 for the current and future occupational workers is 0.001 (Tables D-44 and D-46). This HI is well below the EPA threshold HI of 1.0. The estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.4.4 CFA-08D. The estimated HI for CFA-08D for the current and future occupational workers is 0.001 (Tables D-44 and D-46). This HI is well below the EPA threshold HI of 1.0. The estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.4.5 CFA-08 STP. The estimated HI for CFA-08STP for current and future occupational workers is 0.001 (Tables D-44 and D-46). This HI is well below the EPA threshold HI of 1.0. The estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.4.6 CFA-10. The estimated HI for CFA-10 for current and future occupational workers is 0.001 (Tables D-44 and D-46). This HI is well below the EPA threshold HI of 1.0. The estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.4.7 CFA-12. The estimated HI for CFA-12 for current and future occupational workers is 0.001 (Tables D-44 and D-46). This HI is well below the EPA threshold HI of 1.0. The estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.4.8 CFA-13. The estimated HI for CFA-13 for current and future occupational workers is 0.001 (Tables D-44 and D-46). This HI is well below the EPA threshold HI of 1.0. The estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.4.9 CFA-17/47. The estimated HI for CFA-17/47 for current and future occupational workers is 0.001 (Tables D-44 and D-46). This HI is well below the EPA threshold HI of 1.0. The estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.4.10 CFA-26. The estimated HI for CFA-26 for current and future occupational workers is 0.001 (Tables D-44 and D-46). This HI is well below the EPA threshold HI of 1.0. The estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.4.11 CFA-42. The estimated HI for CFA-42 for current and future occupational workers is 0.001 (Tables D-44 and D-46). This HI is well below the EPA threshold HI of 1.0. The estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.4.12 CFA-46. The estimated HI for CFA-46 for current and future occupational workers is 0.001 (Tables D-44 and D-46). This HI is well below the EPA threshold HI of 1.0. The estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.4.13 CFA-52. The estimated HI for CFA-52 for current and future occupational workers is 0.001 (Tables D-44 and D-46). This HI is well below the EPA threshold HI of 1.0. The estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5 Potential Noncancer Risks: Future Residential Scenario. Table D-48 presents the noncancer risk estimates (i.e., hazard indices) for the future residential scenario. Noncancer

risk estimates are shown for each retained site and for each potentially complete exposure pathway identified for the future resident. Potential risks estimated for this receptor at each retained site are discussed in the sections below. The site-wide risk estimates for the groundwater exposure pathways (i.e., ingestion, dermal contact, inhalation of volatiles during) contribute minimally to the total risk estimate; together, these pathways contribute to less than 0.4 percent of the total risk estimate for each site.

6.5.2.2.5.1 CFA-04. The estimated HI for CFA-04 for the future residential scenario is 60 (Table D-48). This HI exceeds the EPA threshold HI of 1. The majority of the noncancer risk (approximately 97 percent) is associated with ingestion of homegrown produce; mercury contributes most significantly to the hazard quotient calculated for this exposure pathway. The mercury noncancer risk estimate for the homegrown produce pathway is largely based on the assumed soil-to-water partition coefficient (K_d); uncertainties associated with this parameter are discussed in Section 6, Uncertainty Analysis. Some of the noncancer risk (approximately two percent) is associated with soil ingestion; ingestion of mercury contributes most significantly to the HQ estimated for this exposure pathway.

6.5.2.2.5.2 CFA-05. The estimated HI for CFA-05 the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5.3 CFA-07. The estimated HI for CFA-07 for the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5.4 CFA-08D. The estimated HI for CFA-08D for the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5.5 CFA-08STP. The estimated HI for CFA-08STP for the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5.6 CFA-10. The estimated HI for CFA-10 for the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5.7 CFA-12. The estimated HI for CFA-12 for the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5.8 CFA-13. The estimated HI for CFA-13 for the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5.9 CFA-15. The estimated HI for CFA-15 for the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5.10 CFA-17/47. The estimated HI for CFA-17/47 for the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5.11 CFA-26. The estimated HI for CFA-26 for the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5.12 CFA-42. The estimated HI for CFA-42 for the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5.13 CFA-46. The estimated HI for CFA-46 for the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.2.2.5.14 CFA-52. The estimated HI for CFA-52 for the future residential scenario is 0.001 (Table D-48). This HI is well below the EPA threshold HI of 1.0. Over 99 percent of the estimated HI is based on the site-wide HI for inhalation of particulates.

6.5.3 Risk Characterization for COPCs without Toxicity Values

EPA-verified toxicity values are not currently available for three of the COPCs identified for WAG 4 [i.e., benzo(g,h,i)perylene, lead, TPH]. For these COPCs, EPA (1989a) recommends a qualitative, rather than quantitative, evaluation of potential risks. These evaluations are presented below.

Benzo(g,h,i)perylene is a polycyclic aromatic hydrocarbon (PAHs) that was identified as a soil COPC at CFA-13 and CFA-17/47. Benzo(g,h,i)pyrelene does not have any available toxicity data, but the toxicity of contaminants in the PAH family are usually estimated by comparison against the toxicity of benzo(a)pyrene.

Benzo(a)pyrene has been thoroughly studied by the medical community and it has been shown to be a Class B2 carcinogen (i.e., it is a probable human carcinogen). In contrast, there is no evidence from animal toxicity studies that benzo(g,h,i)pyrelene produces any carcinogenic health effects.

The EPA Region III 1E-06 risk-based concentration for benzo(a)pyrene is 0.088 mg/kg, and the 0-10 ft average concentration of benzo(g,h,i)pyrelene at CFA-13 is estimated to be 1.79 mg/kg. The CFA-13 average concentration is 20 times greater than the benzo(a)pyrene risk-based concentration, so if benzo(g,h,i)pyrelene were exactly as toxic as benzo(a)pyrene, its risk would be approximately equal to 2E-05 at CFA-13. Similarly, the 0-10 ft average concentration for benzo(g,h,i)perylene at CFA-17/47 is estimated to be 1.1E-02 mg/kg, so the risk for the contaminant would be equal to 1E-07 if it were as toxic as benzo(a)pyrene. These risk results are upper bound estimates since benzo(g,h,i)pyrelene has been shown to be much less toxic than benzo(a)pyrene.

As shown in Table D-47, the total calculated risk at CFA-13 is 6E-04, and the total risk at CFA-17/47 is 1E-07. As a result, benzo(g,h,i)perylene would not significantly change the risk estimates at either site, even if it were as toxic as benzo(a)pyrene.

6.5.3.1 Lead. Lead is identified as a soil COPC at CFA-10 and CFA-13. Exposure point concentrations for soil lead at CFA-10 and CFA-13 were compared against the EPA recommended

400 mg/kg screening level concentration for lead in residential soil at CERCLA and RCRA Corrective Action sites (OSWER Directive #9355.4-12, EPA 1994b). The 400 mg/kg concentration derived by EPA is based on the pharmacokinetic modeled response (using the Integrated Exposure Uptake Biokinetic [IEUBK] model) of a hypothetical child to lead exposures, based on default parameters. It represents a level below which no further action or study is warranted, provided no special circumstances (e.g., presence of wetlands) warrant further study. The 400 mg/kg concentration is associated with an expected response of a hypothetical child to lead exposure via soil and dust ingestion, and is intended to limit exposure such that the hypothetical child or group of similarly exposed children would have an estimated risk of no more than five percent exceeding the U.S. Centers for Disease Control 10 ug/dL blood lead level of concern (EPA 1994b).

The calculated lead exposure point concentration at CFA-10 for the occupational and residential exposure scenarios are 3,300 mg/kg and 165 mg/kg, respectively. The residential exposure point concentration does not exceed the UESPA (1994b) residential soil lead screening level, indicating that soil lead concentrations at CFA-10 are not expected to pose an unacceptable health risk to children (or adults) under a long-term residential exposure scenario. The occupational lead exposure point concentration at CFA-10 was also compared to the residential screening level because an occupational screening level is not available currently. The occupational lead exposure point concentration exceeds the residential screening level by a factor of eight, indicating that lead levels at CFA-10 may be of concern for occupational workers and future residents who receive exposures from only shallow surface soils.

The calculated lead exposure point concentration at CFA-13 is 261 mg/kg (residential scenario only). The residential exposure point concentration does not exceed the USEPA (1994b) residential soil lead screening level, indicating that soil lead concentrations at CFA-13 are not expected to pose an unacceptable health risk to children (or adults) under a long-term residential exposure scenario.

6.5.3.2 TPH. TPH-d is identified as a COPC at CFA-26, CFA-46, and CFA-52. Potential risks from TPH-d via soil exposure pathways were not assessed in the BRA because detections of TPH-d occur at depths in excess of 3.05 m (10 ft) bgs. TPH-d was, however, retained for the WAG-wide groundwater evaluation. Because of the lack of EPA-approved toxicity values, TPH-d was not included in the risk calculations. However, a comparison can be made of predicted TPH groundwater concentrations to the IDEQ groundwater cleanup levels for TPH. TPH-heating oil is also evaluated in this comparison because this TPH mixture has been reported at CFA-26 (see Section 6.3.3.3). The predicted cumulative groundwater peak concentrations of TPH-diesel and TPH-heating oil are well below the IDEQ groundwater cleanup level of 100 mg/L (see comparison below). The predicted time and concentrations for TPH to reach peak concentrations ranges from 427 to 464 years (see Section 6.3.3.3) at concentrations of 1.1 to 0.00115 mg/L, respectively.

6.6 Uncertainty Analysis

The risk assessment results presented in this BRA are very dependent on the methodologies described in Section 6.3. These analysis methods were developed over a period of several years by INEEL risk management and risk assessment professionals to provide realistic, and yet conservative, estimates of human health risks at WAG 4. Nonetheless, if different risk assessment methods had been used, the BRA would likely have produced different risk assessment results. To ensure that the risk estimates are conservative, health protective assumptions that tend to envelope the plausible upper limits of human health risks are used throughout the BRA. Therefore, risk estimates that may be calculated by other risk assessment methods are not likely to be significantly higher than the estimates presented in Section 6.5.

The BRA results in Section 6.5 are useful for evaluating which WAG 4 release sites require remediation because the results are calculated in a consistent manner. This consistency allows for direct comparison of the risk assessment results for a given release site with the results for every other site included in the evaluation. Changes in a given assumption used in the evaluation would, in general, produce similar changes in the risk results for all of the release sites evaluated. As described in the remainder of this section, the BRA results include inherent uncertainty, but despite this uncertainty, the consistency of the analysis makes the results useful for making remediation decisions.

Uncertainty in this BRA is produced by uncertainty factors in the following four stages of analysis:

1. Data collection and evaluation
2. Exposure assessment
3. Toxicity assessment
4. Risk characterization.

The following subsections discuss each of these four stages in more detail, and

6.6.1 Data Collection and Evaluation Uncertainties

Uncertainties associated with data collection and evaluation are produced by variability in observed concentrations caused by sampling design and implementation, laboratory analysis methods, seasonality, contaminant level variation, and natural concentration variation. Optimizing the usability of sampling data involves quantifying these uncertainties.

The effect of uncertainty introduced from sample collection and analysis is reduced by basing risk estimates on the 95% UCL of the mean for the WAG 4 COPC concentration estimates. The resulting concentration estimates, used to estimate intakes, are an upper bound estimate of the concentrations observed at the retained sites. This approach is health protective and accounts for the uncertainty introduced by sampling, analysis, seasonality, and natural variation.

A major assumption included in the BRA analysis is that all significant sources of contamination at WAG 4 have been identified and sampled. If a source of contamination has not been identified and sampled, the risks from the contamination are not included in the BRA.

CFA-12 includes an example of contamination that may not have been detected in the site's sampling activities. Table 4-1 of the OU 4-09 Track 2 Summary Report (Gianotto et al., 1996) shows that the 1993 sampling of the CFA-12 drain sediments produced maximum detections of cadmium, calcium, mercury, and lead that exceeded INEEL background concentrations. At the time the drains were removed, these relatively low concentrations were not considered to be significant, so the samples that were collected after the removal were not tested for metals. All of the metal contamination that was detected in the 1993 sampling was removed with the drains, but there is a small chance that low levels of undetected metal contamination still exists in the basalt beneath the drains.

One of the first steps in the BRA was a screening of release sites and contaminants (see Section 6.2). The purpose of this screening activity was to help focus the BRA on sites and contaminants that are likely to produce adverse human health effects. The screening process was designed to be conservative so that all sites and contaminants that have a reasonable potential for causing adverse human

health effects would pass the screening, and therefore would be evaluated in the BRA. If in fact the screening process was not conservative enough, and sites or contaminants that could cause adverse human health effects were inappropriately screened out, then the BRA risk results presented in Section 6.5 would be underestimated. A contamination source would have to be small to be inappropriately screened, so any underestimation of risk would be slight if a site or contaminant were inappropriately screened.

Tentatively identified compounds (TICs) were detected at several of the WAG 4 release sites. These compounds were not included in the BRA risk calculations. In accordance with EPA risk assessment guidance (EPA 1989a), the TICs were omitted because they were not detected frequently and because the compounds are not expected to have been released.

All of the release sites evaluated in the BRA have varying levels of uncertainty associated with the contaminant concentrations evaluated in the BRA. Additionally, all of the evaluated concentrations were estimated using conservative assumptions about the nature and extent of contamination at the various release sites. The concentration term uncertainties and conservative assumptions are summarized in Table 6-12.

6.6.2 Exposure Assessment

Uncertainties associated with the exposure assessment are produced by characterizing transport, dispersion, and transformation of COPCs in the environment; establishing exposure settings; and deriving estimates of chronic intake. The initial characterization that defines the exposure setting for a site involves many professional judgments and assumptions. Definition of the physical setting, population characteristics, and selection of the chemicals included in the risk assessment are examples of areas for which a quantitative estimate of uncertainty cannot be achieved because of the inherent reliance on professional judgment. Assumptions and supporting rationale regarding these types of parameters, along with the potential impact on the uncertainty (i.e., overestimation or underestimation of uncertainty), are included in Table 6-12.

An aspect of the risk assessment that tends to exaggerate risk results is the evaluation of contaminants with background concentrations that produce calculated risks in excess of 1E–06. An example of this type of contaminant is arsenic. This metal is commonly detected in INEEL soils at concentrations that are slightly higher than the accepted background concentration. Arsenic, however, is not associated with known waste producing processes at WAG 4. Detected concentrations of arsenic are likely to be attributable to background concentrations; detected concentrations that slightly exceed accepted background concentrations are likely due to variations in background levels from site to site. For this reason, and because the toxicity values for arsenic are conservative (i.e., high slope factor, low reference dose), risks are likely to be overestimated at those sites at which arsenic was retained as a COPC.

As discussed in Section 4, the contaminant source terms evaluated in the BRA were calculated by "volume weighting" measured site concentrations. Volume weighting refers to the process of measuring contaminant concentrations at various locations and depths at a given release site, estimating the volume of soil that is represented by a given measurement or group of measurements, and deriving average contaminant concentrations at the site by weighting the measurements with the associated soil volumes. This process produces reasonable estimates of a site's average contaminant concentrations as long as the site was thoroughly sampled. If the contamination at a given site was not well defined, volume weighting could produce errors in the site's average concentrations. These errors could either over or under estimate the true average contaminant concentrations at the site, depending on the results of the site's sampling

investigation. Details of the sampling investigations evaluated in the RI/FS are discussed in Section 4. and summarized in Table 6-12.

The only contaminant loss mechanism considered in the BRA is radioactive decay. Other loss mechanisms such as leaching, wind erosion, etc., are assumed to be negligible. The reason for this assumption is that environmental sampling has shown that most contaminants do not migrate from most INEEL release sites. As a result of this observation, very few studies have been performed to evaluate these mechanisms, so there is very little site-specific information available to estimate the exact effects of these removal mechanisms.

Omitting removal mechanisms other than radioactive decay tends to overestimate risk for all exposure routes because it leads to assuming a given mass of contaminant will cause exposures to multiple exposure routes. For example, leaching is omitted in the soil pathway analysis even though leaching is the mechanism that produces the contamination evaluated in the groundwater pathway analysis. As a result of the omission, a given mass of contamination can affect both the soil pathway and groundwater pathway risk results. Upper bound infiltration and contaminant leachability assumptions are used in the groundwater pathway analysis to estimate future groundwater contaminant concentrations. Applying these same upper bound assumptions to the soil pathway analysis would likely produce an underestimation of soil pathway risks. To avoid this possibility, leaching is omitted from the soil pathway analysis, so that upper bound risk results are calculated for both the soil pathway and groundwater pathway exposure routes.

The estimated residential exposure (i.e., chemical intake) to mercury via the homegrown produce ingestion exposure pathway contributes to over 90 percent of the estimated HI for CFA-04 which includes the pond area, the mercury retort equipment staging area, and the windblown area The estimated intake of mercury from this exposure pathway is largely driven by the assumed value of 100 for the K_d (soil-to-water partition coefficient). The assumed value is based on the DOE (1994) suggested K_d values. The suggested value of 100 is conservative; other K_d values in the literature are shown to be as much as an order of magnitude lower (Baes et al. 1984). Reduction of the K_d by an order of magnitude can result in reduction of the estimated homegrown produce pathway HI by a factor of 6.

One of the purposes of the BRA is to estimate upper bound risks from WAG 4 contaminant releases based on best available site specific information. Omitting removal mechanisms that have not been studied on a site specific basis, and which are likely to produce only small errors in the calculated risk results, is consistent with this objective.

The sites containing radionuclide contamination were examined for on-site risk from external radiation exposure. However, external radiation exposure from gamma emitting radionuclides may extend outward from a site boundary if the radiation is attenuated only by air, so external radiation dose may be additive if a receptor is in the proximity of several sites containing radionuclide soil contamination. Risk results for the external radiation pathway (see Tables D-43, - 45, and -47) indicate that potential risks from external radiation exceed 1E-04 to 1E-06 EPA acceptable excess cancer risk range for only one of the eleven quantitatively evaluated for risk. Previous external radiation risk estimates from other INEEL sites with radionuclide activities greater than those measured at WAG 4 have been insignificant. Therefore, external radiation risks from doses that may be received outside individual site boundaries are likely to be insignificant and were not evaluated.

Table 6-12. Summary of Source Term Uncertainties for the OU 4-13 BRA.

Release Sites		Source Term Uncertainties and/or Assumptions
CFA-13	Dry Well (South of CFA-640)	Exposure point concentrations used for depth interval and volume-weighted concentrations are based on the 95% UCL or maximum detected concentration, whichever is less, instead of average (arithmetic mean) concentrations. Of the 19 calculated site-specific exposure point concentrations, all are based on the maximum detected concentration. The area of contamination is assumed to exist uniformly across the site, even though only two of the nine COPCs were detected in 100% of the site-wide samples. The other COPCs were detected in at least 14.3% of the samples. Contamination is assumed to exist down to 9.1 m (30 ft), even though positive detections of chemicals in the vadose zone are reported only to a depth of 6.1 m (20 ft). The depth of contamination is based on the assumption that mobility of chemicals suspended in liquids in the vadose zone (i.e., waste water) at CFA-13 is 3 m (10 ft). This assumption is made to ensure that potential risks from exposures at CFA-13 are not underestimated (Section 6). These assumptions may cause the calculated risks at the site to be overestimated.
CFA-15	Dry Well (CFA-674)	Exposure point concentrations used for depth interval and volume-weighted concentrations are based on the 95% UCL or maximum detected concentration, whichever is less, instead of average (arithmetic mean) concentrations. Of the three calculated site-specific exposure point concentrations, all are based on the maximum detected concentration. The one identified COPC was detected in 100% of the site-wide samples. The area of contamination is assumed to exist uniformly across the site. Contamination is assumed to exist down to 8 m (26 ft), even though positive detections of chemicals in the vadose zone are reported only to a depth of 4.9 m (16 ft). The depth of contamination is based on the assumption that mobility of chemicals suspended in liquids in the vadose zone (i.e., waste water) at CFA-15 is 3 m (10 ft). This assumption is made to ensure that potential risks from exposures at CFA-15 are not underestimated (Section 6). These assumptions may cause the calculated risks at the site to be overestimated.
CFA-04	Pond (CFA-674)	Exposure point concentrations used for depth interval and volume-weighted concentrations are based on the 95% UCL or maximum detected concentration, whichever is less, instead of average (arithmetic mean) concentrations. Of the 18 calculated site-specific exposure point concentrations, six are based on the maximum detected concentration. The area of contamination is assumed to exist uniformly across the site, even though only two of the six COPCs were detected in 100% of the site-wide samples. The other COPCs were detected in at least 48.0% of the samples. The area of contamination is assumed to exist uniformly across the site. Contamination is assumed to exist down to 5.5 m (18 ft), even though positive detections of chemicals in the vadose zone are reported only to a depth of 2.4 m (8 ft). The depth of contamination is based on the assumption that mobility of chemicals suspended in liquids in the vadose zone (i.e., waste water) at CFA-04 is 3 m (10 ft). This assumption is made to ensure that potential risks from exposures at CFA-04 are not underestimated (Section 6). These assumptions may cause the calculated risks at the site to be overestimated.

Table 6-12. (continued).

Release Sites		Source Term Uncertainties and/or Assumptions
CFA-17/47	Fire Department Training Area (bermed) and Fire Station Chemical Disposal	Exposure point concentrations used for depth interval and volume-weighted concentrations are based on the 95% UCL or maximum detected concentration, whichever is less, instead of average (arithmetic mean) concentrations. The area of contamination is assumed to exist uniformly across the site, even though none of the COPCs was detected in more than 5% of the site-wide samples. Contamination is assumed to exist down to 4 m [13 ft], even though positive detections of chemicals in the vadose zone are reported only to a depth of 0.9 m (3 ft). Sampling depths did occur at 7 m (23 ft) bgs, but results from the 0.9 to 7 m (3 ft to 23 ft) bgs depth interval did not indicate the presence of COPCs. The depth of contamination is based on the assumption that mobility of chemicals suspended in liquids in the vadose zone (i.e., waste water) at CFA-17/47 is 3 m (10 ft). This assumption is made to ensure that potential risks from exposures at CFA-17/47 are not underestimated (Section 6). These assumptions may cause the calculated risks at the site to be overestimated.
CFA-07	French Drains E/S (CFA-633)	Exposure point concentrations used for depth interval and volume-weighted concentrations are based on the 95% UCL or maximum detected concentration, whichever is less, instead of average (arithmetic mean) concentrations. All of the four calculated site-specific exposure point concentrations are based on the maximum detected concentration. The area of contamination is assumed exist uniformly across the site (both drains), even though only three of the four COPCs were detected in 100% of the number of site-wide samples. The other COPC was detected in 66.7 % of the site-wide samples. Contamination is assumed to exist down to 7.2 m [23.5 ft], even though positive detections of chemicals in the vadose zone are reported only to a depth of 4.1 m (13.5 ft). The depth of contamination is based on the assumption that mobility of chemicals suspended in liquids in the vadose zone (i.e., waste water) at CFA-07 is 3 m (10 ft). This assumption is made to ensure that potential risks from exposures at CFA-07 are not underestimated (Section 6). These assumptions may cause the calculated risks at the site to be overestimated.
CFA-12	French Drains (2) (CFA-690) [South Drain only]	Exposure point concentrations used for depth interval and volume-weighted concentrations are based on the 95% UCL or maximum detected concentration, whichever is less, instead of average (arithmetic mean) concentrations. Of the seven calculated site-specific exposure point concentrations, all are based on the maximum detected concentration. The area of contamination is assumed to exist uniformly across the south drain. Contamination is present in a basalt fracture at a depth of 2.6 m (8.5 ft). The depth to basalt is assumed to occur at 2.4 m (8 ft). Soils at this site have been excavated and backfilled with clean fill; residual contamination is in the basalt. Inclusion of this site for quantitative evaluation in the BRA is conservative because the soil has already been remediated. It is assumed that COPCs are contained within the soil above the 2.6 m (8.5 ft) level. It is also assumed that COPCs may occur from 0 to 2.6 m (0 to 8.5 ft) for the future residential scenario even though residual contamination is likely to remain immobile in the basalt. These assumptions may cause the calculated risks at the site to be overestimated.

Table 6-12. (continued).

Release Sites		Source Term Uncertainties and/or Assumptions
CFA-08	Drainfield	Exposure point concentrations used for depth interval and volume-weighted concentrations are based on the 95% UCL or maximum detected concentration, whichever is less, instead of average (arithmetic mean) concentrations. Of the nine calculated site-specific exposure point concentrations, seven are based on the maximum detected concentration. The area of contamination is assumed to exist uniformly across the drainfield, even though site-wide detection frequencies for each of the three COPCs are no greater than 72.3%. Contamination is assumed to exist at 10 m (32 ft) bgs. The depth to basalt is assumed to occur at 10 m (32 ft). It is assumed that COPCs will not migrate downward beyond 10 m (32 ft) due to the presence of basalt at 10 m (32 ft). These assumptions may cause the calculated risks at the site to be overestimated.
CFA-08	Sewage Treatment Plant (CFA-691)	Exposure point concentrations used for depth interval and volume-weighted concentrations are based on the 95% UCL or maximum detected concentration, whichever is less, instead of average (arithmetic mean) concentrations. Both of the two calculated site-specific exposure point concentrations are based on the 95% UCL. The area of contamination is assumed to exist uniformly across the sewage treatment plant, even though site-wide detection frequencies for the two COPCs are 73.1% and 100%. Contamination is assumed to exist down to 11.3 m [37.25 ft], even though positive detections of chemicals in the vadose zone are reported only to a depth of 8.3 m (27.25 ft). The depth of contamination is based on the assumption that mobility of chemicals suspended in liquids in the vadose zone (i.e., waste water) at CFA-08 is 3 m (10 ft). This assumption is made to ensure that potential risks from exposures at CFA-08 are not underestimated (Section 6). These assumptions may cause the calculated risks at the site to be overestimated.
CFA-10	Transformer Yard Oil Spills	Exposure point concentrations used for depth interval and volume-weighted concentrations are based on the 95% UCL or maximum detected concentration, whichever is less, instead of average (arithmetic mean) concentrations. The one calculated site-specific exposure point concentration for this site is based on the maximum detected concentration. The area of contamination is the area of the site based on process knowledge that there was no specific pattern of waste disposal. The maximum depth of contamination is 0.15 m (0.5 ft) bgs based on depths of measured concentrations. For purposes of evaluating residential exposure pathways, contamination from 0 to 3.05 m (0 to 10 ft) soil interval is assumed. This assumption is made to ensure that potential risks from exposures at CFA-10 are not underestimated (Section 6). These assumptions may cause the calculated risks at the site to be overestimated.
CFA-26	CFA-760 Pump Station Fuel Spill	CFA-26 was retained for groundwater modeling purposes. It is assumed that contamination is uniformly distributed across the site. TPH was detected in 100% of the number of samples at a depth interval of 1.5 to 3.4 m (5 to 11.25 ft) bgs for CFA-26. Basalt was encountered at a depth range of 2.9 to 3.4 m (9.5 to 11.25 ft) bgs. These assumptions may cause the calculated risks at the site to be overestimated due to the possibility that the COPCs in groundwater may not reach receptors.

Table 6-12. (continued).

Release Sites		Source Term Uncertainties and/or Assumptions
CFA-42	Tank Farm Pump Station Spills	Exposure point concentrations used for depth interval and volume-weighted concentrations are based on the 95% UCL or maximum detected concentration, whichever is less, instead of average (arithmetic mean) concentrations. The only calculated site-specific exposure point concentration is based on the 95% UCL. The area of contamination is assumed to exist uniformly across the site, even though the COPC detection frequency is less than 5%. Contamination is assumed to exist down to 6.1 m [20 ft]. The depth to basalt is assumed to occur at 6.1 m (20 ft). Soils at this site have been excavated and backfilled with clean fill; residual contamination is in the basalt. Inclusion of this site for quantitative evaluation in the BRA is conservative because the soil has already been remediated.
CFA-46	Cafeteria Oil Tank Spill (CFA-721)	CFA-46 was retained for groundwater modeling purposes. It is assumed that contamination is uniformly distributed across the site. Of the five Groundwater COPCs evaluated, only one was detected in 100% of the number of samples, while the other COPCs were detected in 71.4% of the number of samples. Contamination is assumed to exist at 4.9 m (16 ft) bgs. Basalt was encountered at 4.9 m (16 ft) bgs. These assumptions may cause the calculated risks at the site to be overestimated due to the possibility that the COPCs in groundwater may not reach receptors.
CFA-05	Motor Pool Pond	CFA-05 was retained for groundwater modeling purposes. It is assumed that contamination is uniformly distributed across the site. Contamination was detected from 0 to 5.8 m (0 to 19 ft) bgs. Of the 10 groundwater COPCs, nine were detected in 100% of the number of site-wide samples and the remaining COPC was detected in 86.5% of the number of site-wide samples. Basalt was encountered at 5.8 m (19 ft) bgs. These assumptions may cause the calculated risks at the site to be overestimated due to the possibility that the COPCs in groundwater may not reach receptors.
CFA-52	Diesel Fuel UST (CFA-730) at Bldg CFA-613 Bunkhouse	CFA-52 was retained for groundwater modeling purposes. It is assumed that contamination is uniformly distributed across the site. TPH was detected in 100% of the number of samples at a depth interval of 4.6 to 5 m (15 to 16.5 ft) bgs. Basalt was encountered at 4.9 m (16 ft) bgs. These assumptions may cause the calculated risks at the site to be overestimated due to the possibility that the COPCs in groundwater may not reach receptors.

6.6.3 Toxicity Assessment

Several important measures of toxicity are needed to conduct an assessment of risk to human health. RfDs are applied to the oral and inhalation exposure to evaluate noncarcinogenic and developmental effects, and SFs are applied to the oral and inhalation exposures to carcinogens. RfDs are derived from NOAELs or LOAELs and the application of uncertainty factors (UFs) and modifying factors (MFs). UFs are used to account for the variation in sensitivity of human subpopulations and the uncertainty inherent in extrapolation of the results of animal studies to humans, while MFs account for additional uncertainties in the studies used to derive the NOAEL or LOAEL. Uncertainty associated with SFs is accounted for by an assigned weight-of-evidence rating that reflects the likelihood that the toxicant is a human carcinogen. Weight-of-evidence classifications are tabulated and included in Table D-42, while a discussion of the UFs and MFs used to derive RfDs are presented in Section 6.4.

6.6.4 Risk Characterization

The last step in the risk assessment is risk characterization. As discussed in Section 6.5, risk characterization is the process of integrating the results of the exposure and toxicity assessments. The uncertainties defined throughout the analysis process are combined and presented as part of the risk characterization to provide an understanding of the overall uncertainty in the estimate of risk. Table 6-13 presents this qualitative assessment of uncertainty. See Section 8 for a summary of WAG 4 risks.

6.6.5 Sensitivity Analysis

A sensitivity analysis was performed to assess potential difference in risk estimates given changes to the exposure assumptions used in the human health assessment for OU 4-13. The objective of the analysis was to illustrate the magnitude of risk reduction achieved by varying values for selected exposure parameters (e.g., varying the exposure duration). To meet this objective, three baseline assumptions for a hypothetical future resident were modified:

1. Keeping the exposure point concentrations constant, the exposure parameters were modified to reflect probable and more realistic future resident exposures

2. Keeping the exposure point concentrations constant, the exposure parameters were modified to reflect conditions for a modified (i.e., not full time) resident

3. Keeping the exposure assessment assumptions constant, alter the exposure point concentrations to reflect average rather than upper bound conditions.

The following sections discuss the assumptions used in the sensitivity analysis and the observed impacts to the risk estimates.

6.6.5.1 Exposure Parameter Sensitivity. Table 6-14 illustrates the exposure assessment parameters that were altered for the future resident and the modified resident in the sensitivity analysis. Generally, the parameters used for the future resident (averaging time, exposure duration, exposure frequency, exposure time and ingestion rate) reflect more typical residential exposures than the parameter values used in the BRA base case analysis (see Section 6.5). The only parameters altered for the modified resident were exposure frequency and exposure time. Parameters not shown here are assumed to be consistent with those used in the BRA base case analysis.

Table 6-13. BRA Human Health Assessment Uncertainty Factors.

Uncertainty factor	Effect of uncertainty	Comments and Assumptions
Source term assumptions	May overestimate risk	All contaminants are assumed to be completely available for transportation away from the source zone. In reality, some contaminants may be chemically or physically bound to the source zone and unavailable for transport.
Natural infiltration rate	May overestimate risk	A conservative value of 10 cm/year was used for this parameter.
Moisture content	May overestimate or underestimate risk	Soil moisture contents vary seasonally in the upper vadose zone and may be subject to measurement error.
Water table fluctuations	May slightly overestimate or underestimate risk	The average value used is expected to be representative of the depth over the 30-year exposure period.
Mass of contaminants in soils is estimated by assuming a uniform contamination concentration in the source zone.	May overestimate or underestimate risk	There is a possibility that most of the mass of a contaminant at a site may exist in a hotspot that was not detected by sampling. If this condition existed, the mass of the contaminant used in the analysis might be underestimated. However, 95% UCLs or maximum detected contamination were used for all mass calculations, and these concentrations are assumed to exist at every point in each waste site; therefore, the mass of contaminants used in the analysis is probably overestimated.
Plug flow assumption in groundwater transport	Could overestimate or underestimate risk	Plug flow groundwater models will likely estimate a greater mass of contaminants will be transported to the aquifer than would occur under natural conditions, with respect to concentrations because dispersion is neglected, and mass fluxes from the source to the aquifer differ only by the time delay in the unsaturated zone (the magnitude of the flux remains unchanged). For nonradiological contaminants, the plug flow assumption is conservative because dispersion as completed in the models is not allowed to dilute the contaminant groundwater concentrations. For radionuclides, the plug flow assumption may or may not be conservative. Based on actual travel time, the radionuclide groundwater concentrations could be overestimated or underestimated because a longer travel time allows for more decay. If the concentration decrease because the travel time delay is larger than the neglected dilution from dispersion, the model will not be conservative.
All infiltration into WAG 4 is assumed to occur through the contaminated sites	Will overestimate risk	Infiltration that normally occurs between contaminated sites is assumed to be concentrated on contaminated sites. This assumption results on a probable overestimate of risk because more water is available in the model calculation to carry contaminants to the aquifer.
No migration of contaminants from the soil source prior to 1994	Could overestimate or underestimate risk	The effect of not modeling contaminant migration from the soil before 1994 is dependent on the contaminant half-life, radioactive in growth, and mobility characteristics.
Contaminant source terms assumed to be lognormally distributed	Could overestimate risk	If sampling data at a given site fits a normal distribution rather than a lognormal distribution, the 95% UCL of the near concentrations calculated for the site could be as much as 50% too high. EPA from Superfund sites are lognormally distributed (EPA 1992).
Chemical form assumptions	Could overestimate or underestimate risk	In general, the methods and inputs used in contaminant migration calculations, including assumptions made about the chemical forms of contaminants were chosen to err on the protective side. All contaminant concentration and mass are assumed available for transport. This assumption results in a probable overestimate of risk.

Table 6-13. (continued).

Uncertainty factor	Effect of uncertainty	Comments and Assumptions
Exposure scenario assumptions	May overestimate risk	The likelihood of future scenarios has been qualitatively evaluated as follows: resident - improbable industrial - credible. The likelihood of future onsite residential development is small. If future residential use of this site does not occur, then the risk estimates calculated for future onsite residents are likely to overestimate the true risk associated with future use of this site.
Exposure parameter assumptions	May overestimate risk	Assumptions regarding media intake, population characteristics, and exposure patterns may not characterize actual exposures.
Receptor locations	May overestimate risk	Groundwater ingestion risks are calculated for a point at the downgradient edge of an equivalent rectangular area. The groundwater risk at this point is assumed to be the risk from groundwater ingestion at every point within the WAG 4 boundaries. Changing the receptor location will affect only the risks calculated for the groundwater pathway because all other risks are site-specific or assumed constant at every point within the WAG 4 boundaries.
For the groundwater pathway analysis, all contaminants are assumed to be homogeneously distributed in a large mass of soil.	May overestimate or underestimate risk	The total mass of each COPC is assumed to be homogeneously distributed in the soil volume beneath the WAG 4 retained sites. This assumption tends to maximize the estimated groundwater concentrations produced by the contaminant inventories because homogeneously distributed contaminants would not have to travel far to reach a groundwater well drilled anywhere within the WAG 4 boundary. However, groundwater concentrations may be underestimated for a large mass of contamination located in a small area with a groundwater well drilled directly downgradient.
The entire inventory of each contaminant is assumed to be available for transport along each pathway	May overestimate risk	Only a portion of each contaminant's inventory is actually transported by each pathway.
Exposure duration	May overestimate risk	The assumption that an individual will work or reside at a contaminated site for 25 or 30 years is conservative. Short-term exposures involve comparison to subchronic toxicity values, which are generally less restrictive than chronic values.
Noncontaminant-specific constants (not dependent on contaminant properties)	May overestimate risk	Conservative or upper limit values were used for all parameters incorporated into intake calculations.
Exclusion of some hypothetical pathways from the exposure scenarios	May underestimate risk	Exposure pathways are considered for each scenario and eliminated only if the pathway is either incomplete or negligible compared to other evaluated pathways.
Poorly defined dermal absorption factors (ABS) values for most WAG 4 contaminants	May underestimate risk	A lack of ABS values for most WAG 4 contaminants may mean that dermal absorption risks are higher than expected. The possibility of unacceptable dermal absorption from soil risks being produced by WAG 4 contaminants is considered to be unlikely.
Model does not consider biotic decay	May overestimate risk	Biotic decay would tend to reduce contamination over time.

Table 6-13. (continued).

Uncertainty factor	Effect of uncertainty	Comments and Assumptions
Occupational intake value for inhalation	Slightly overestimates risk	Standard exposure factors for inhalation have the same value for occupational as for residential scenarios although occupational workers. The time of exposure is assumed to be the same in the risk calculations for occupational workers as it is for residents.
Use of cancer SFs	May overestimate risk	Nonradionuclide SFs are associated with upper 95th percentile confidence limits and radionuclide SFs are central estimates of cancer incidence per unit intake. They are considered unlikely to underestimate true risk.
Toxicity values are derived primarily from animal studies	May overestimate or underestimate risk	Extrapolation from animal to humans may induce error caused by differences in absorption, pharmacokinetics, target organs, enzymes, and population variability
Toxicity values are derived primarily from high doses; most exposures are at low doses	May overestimate or underestimate risk	Assumes linearity at low doses. Tends to have conservative exposure assumptions.
Toxicity values and classification of carcinogens	May overestimate or underestimate risk	Not all values represent the same degree of certainty. All are subject to change as new evidence becomes available.
Lack of SFs	May underestimate risk	COPCs without SFs, may or may not be carcinogenic through the oral pathway.
Lack of RfDs	May underestimate risk	COPCs without RfDs may or may not have noncarcinogenic adverse effects.
Risk/HQs are combined across pathways	May overestimate risk	Not all of the COPC inventory will be available for exposure through all applicable exposure pathways.

Table 6-14. Sensitivity analysis exposure parameter values and sources.

Exposure Parameter	Modified Parameter Value	Rationale/Source
Averaging Time (Noncarcinogenic)		
Future resident	7,300 days	Adult, noncarcinogenic, 20 years × 365 days. Exposure factors handbook indicates 77% of residents move prior to 20 years.
Exposure duration		
Future resident	20 years	Exposure factors handbook indicates 77% of residents move prior to 20 years.
Exposure frequency		
Future resident (soil exposure)	305 days/year	Assumes no exposure to soil for 60 days/year during periods of snowpack and/or frozen ground (based on professional judgement)
Modified resident	150 days/year	Assumed exposure frequency (based on professional judgement)
Exposure time		
Future resident	12 hours/day	Exposure factors handbook indicates an average of 730 minutes/day are spent on non-residential activities
Modified resident	0.25 hours/day	Assumed exposure time (based on professional judgement)
Ingestion rate		
Future residential (soil)	60.5 mg/day	Exposure factors handbook provides mean ingestion rate
Future residential (water)	1.36 L/day	Exposure factors handbook provides mean ingestion rate

Applying the more realistic exposure parameter assumptions to the future resident resulted in a reduction in the total risk estimated by 50 to 60 percent (i.e., a risk reduction factor of 0.5 to 0.4). The modified resident assumptions resulted in a reduction in the total risk estimated by 60 to 99 percent (i.e., a risk reduction factor of 0.4 to 0.01). For example, the total excess cancer risk estimate for CFA-04 under the future residential baseline conditions is 4E-05. Application of a risk reduction factor of 0.4 to this estimate would result in a risk of 1.6E-05. For the two cases considered (i.e., the future resident and the modified resident), modifying the resident assumptions from a full-time resident to a part-time resident resulted in a greater reduction in risk than assigning more realistic exposure parameters.

***6.6.5.2* Exposure Point Concentration Sensitivity.** Altering the soil exposure point concentrations for the future residential baseline scenario to reflect average rather than 95% UCL or maximum conditions resulted in a reduction in the total excess cancer risk estimated by 3 percent to 73

percent (i.e., a risk reduction factor of 0.97 to 0.27). For example the total excess risk estimate for CFA-04 under residential baseline conditions is 4E-05. Applying a risk reduction factor of 0.15 to this estimate would result in a risk of 1E-05.

6.7 References

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